CHAPTER 6

UPLAND HABITATS

6-1. General. Upland habitats encompass a variety of terrestrial communities ranging from bare soil to dense forest. In the broadest interpretation, upland habitat occurs on all but the most disturbed disposal sites. For example, a gravelly and bare disposal site may provide nest sites for killdeer or tern species; weedy growth may provide cover for raccoons or a food source for seed-eating birds; and water collected in desiccation cracks may provide breeding habitat for mosquitoes. The essential fact is that man-made habitats will develop regardless of their management; however, the application of sound management techniques will greatly improve the quality of those habitats (item 72)

6-2. Upland Habitat Development Considerations. Upland habitat development has potential at hundreds of disposal sites throughout the United States. Its implementation is largely a matter of the application of well-established agricultural and wildlife management techniques.

a. Advantages. Upland habitat development as a disposal alternative has several distinct advantages:

(1) Adaptability.

(2) Improved public acceptance.

(3) Creation of biologically desirable habitats.

(4) Elimination of problem areas.

(5) Low-cost enhancement or mitigation.

(6) Compatibility with subsequent disposal.

The principles and applications of this alternative are adaptable to virtually any upland disposal situation. Regardless of the condition or location of a disposal area, considerable potential exists to convert it into a more productive habitat. Small sites in densely populated areas may be keyed to small animals adapted to urban life, such as seed-eating birds and squirrels. Larger tracts may be managed for a variety of wildlife including waterfowl, game mammals, and rare or endangered species. The knowledge that a site will ultimately be developed into a useful area, be it a residential area, a park, or wildlife habitat, improves public acceptance. Many idle and undeveloped disposal areas that are now sources of local irritation or neglect would directly benefit from upland development, and such development may well result in more ready acceptance of future disposal projects. Upland habitat development will usually add little to the cost of disposal operations. Standard procedures may involve liming, fertilizing, seeding, and mowing. A typical level of effort would be similar to that applied for erosion control at most construction sites and considerably less than that encountered in levee maintenance. Unless the target habitat is forest, this type of habitat will generally be compatible with subsequent disposal operations. In most situations, a desirable vegetative cover can be produced in one growing season. Subsequent disposal would simply require recovery of the lost habitat. Indeed, the maintenance of a particular vegetation stage may require periodic disposal to retard or set back succession (item 73).

b. Disadvantages. The disadvantages of upland habitat development are potential public opposition to subsequent disposal and possible necessity of long-term management. The development of a biologically productive area at a given site may discourage subsequent disposal or modification of land use at that site. This problem could be avoided by the clear identification of future plans prior to habitat development, or by the establishment and maintenance of biological communities recognized as being most productive in the earlier stages of succession. In the latter case, subsequent disposal may be a necessary management tool. Some habitat types will require management. For example, if annual plants such as corn are selected for establishment, then yearly planting will be necessary. If the intent is to maintain a grassland or open-field habitat, it may be necessary to mow the area every 2 to 5 years to retard woody vegetation. In most cases, it will be possible to establish very low maintenance habitats, but if the intent is to establish and perpetuate a given habitat type, long-term management will be essential and may be expensive.

6-3. Guidelines for Upland Development.

a. Upland Habitat Needs and Assessments. Those upland habitats in limited supply should be identified and the opportunity for additional habitat assessed. Public attitudes are of particular consequence in the implementation of this alternative, and public opinion should be actively sought. Site selection should be made with a particular target habitat in mind as the importance of other habitats will be greatly influenced by the needs and attributes of the surrounding area. The chemical and physical properties and the relative quantities of different types of dredged material should be evaluated to determine the characteristics of the soil to be used in the habitat development. Several remedial treatments are possible. For example, it may be possible to improve the agricultural characteristics of the surface layer by top dressing the site with material selected for its agronomic characteristics. It may also be possible to bury a problem soil by capping it with a layer of clean material.

b. Planning and Design.

(1) Assuming that upland habitat development has been selected as a disposal alternative or as an enhancement measure, habitat planning and design guidelines are indicated in Figure 6-1. The criteria discussed under site

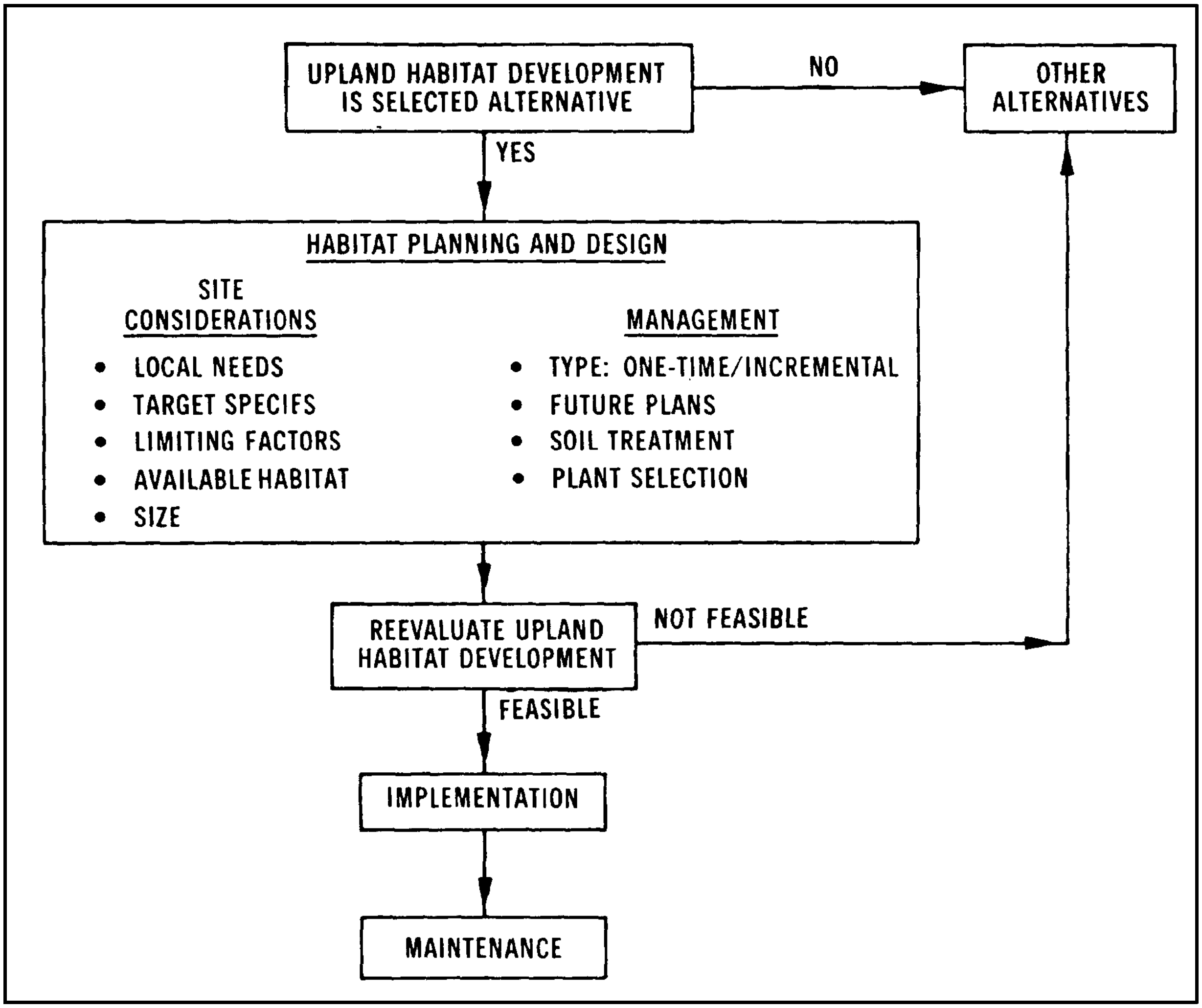

Figure 6-1. Procedural guidelines for selection of upland habitat development

considerations are applicable regardless of whether the site is a new or previously used disposal area. Local needs and thereby target wildlife species will be determined primarily by the desires of state wildlife agencies and those of the public. These needs are likely to reflect local perception of the value of wildlife. If the area has a strong hunting tradition, the emphasis may be on game animals. If there is strong agency concern for an endangered species, that may be the emphasis. In many cases, a target species per se will not be identified. Rather, a grouping such as "songbirds" or "small game" will be designated. The list of target species must be evaluated in light of the available habitat surrounding the site and the size of the disposal site. The size of a disposal area will seldom be large enough to exert a significant impact on regional animal populations if it only duplicates existing habitat types. Therefore, the success of the site will usually be determined by its ability to enhance surrounding habitats or remedy limiting environmental factors.

(2) Basic management decisions will depend on the type of disposal and future plans at the site. If one-time disposal with periodic maintenance is planned, the management plan may be quite flexible. One-time disposal without management indicates the need to establish a plant community that is relatively self-sustaining. If periodic disposal is planned, plant communities that are rapidly functional are advised. Properly planned, periodic disposal could be considered a wildlife management option used to control succession or diversify the habitat and avoid confrontation regarding subsequent activities. Future plans for any habitat development site should be well documented and understood by interested agencies and the public prior to implementation.

(3) Soil treatment and plant selection are closely related and can proceed after determination of the type of disposal, identification of the characteristics of the dredged material, and determination of target species have been completed. Soil treatment may include a variety of activities such as burying problem materials, dewatering, mixing materials to obtain improved soil characteristics, leaching, fertilization, and liming (Figure 6-2). Plant selection will be dictated by soil conditions and habitat preferences. In many situations it will be possible to identify highly desirable natural plant communities near the disposal area. Development of site conditions (soil, elevation, diversity) on dredged material that are similar to those of desirable plant communities will encourage natural invasion and natural development of similar communities. When this is possible, a considerable savings in planting and maintenance costs may be realized.

c. Reevaluation and Implementation. If, upon reevaluation, the upland habitat development alternative remains feasible, the project may be implemented and subsequently maintained. Implementation will be highly site specific but should present few difficulties beyond the problems typically encountered in contracting new or unusual work. Advice from local wildlife biologists and soil scientists may prove invaluable in this stage.

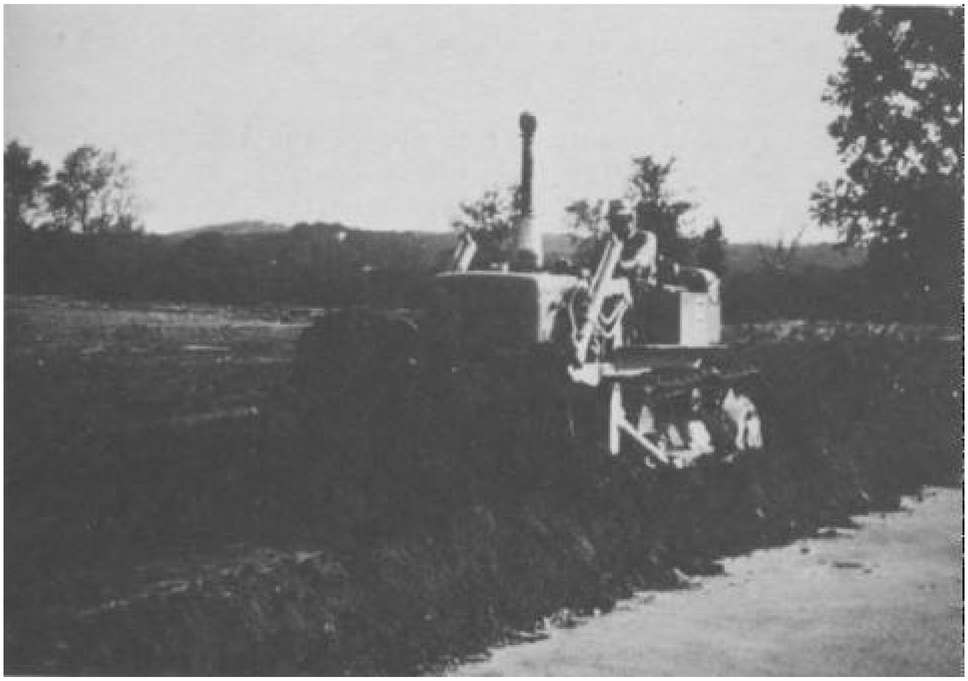

Figure 6-2. Mixing layers of silty and sandy dredged material at Nott Island upland site, Connecticut River, Connecticut

6-4. Upland Site Development.

a. Site selection. Two types of upland habitat development sites have potential beneficial use: older, existing sites where habitat development and enhancement occurred, and planned sites where upland habitat development is part of the project goal. In both cases, several factors determine selection of the best possible site: availability, disposal need capacity, proximity to dredging area, physical and engineering characteristics, environmental and social acceptability, tidal and current considerations, and habitat development feasibility.

b. Site characterization. After the upland disposal site has been selected for development, field and laboratory investigations of the site and related areas should be initiated. If the site is an older disposal area to be reclaimed, it and the surrounding area should be evaluated physically and biologically to assess its potential for habitat development and determine necessary action. If dredging and disposal operations are involved, it will be necessary to add information related to the site’s capacity, need for and design of a protective or retention structure, and construction details. This information should be collected in conjunction with characterization of the sediments to be dredged. Physical, biological, socioeconomic, and engineering tests should be made to determine site suitability (items 32 and 62) and acceptance. Target wildlife species should be identified, and other potential upland objectives such as site stability and multiple habitat use should be considered.

c. Vegetation establishment. Since upland habitat is developed primarily for wildlife and less often for erosion control, it is important to key in on target species that will use the disposal site. An excellent example is the Nott Island site in the Connecticut River, Connecticut, where a mixture of grasses and legumes was planted as a nesting and grazing meadow for waterfowl, deer, and small mammals (Figure 6-3). Although an animal's habitat consists of a wide variety of components, vegetation is by far the most important. Vegetation growth form, height, density, placement, diversity or uniformity, seasonal changes, biomass, and hardiness strongly influence species composition, abundance, and well-being of wildlife. Secondary objectives of recreation, aesthetics, erosion control, and soil quality also depend in part on

Figure 6-3. Nott Island habitat development site, showing the planted nesting and grazing meadow after 5 years of development

vegetation. These relationships make it necessary to begin consideration of the ultimate vegetation of the site early in the planning process. Three methods of upland vegetation establishment exist: allowing natural plant invasion and establishment, planting selected species, and combining natural establishment with planned propagation.

(1) Natural invasion and establishment. The ability of propagules to reach the upland site is the most important factor in describing the potential for natural colonization on dredged material. This ability increases as the distance from a propagule source decreases and as the size of the site and ease with which the propagule can be transported increase. Propagules may be transported over a distance by wind or water; by attaching themselves to an animal's fur, feathers, or feet; by being ingested and excreted by an animal; or by attaching to a human. Secondary factors in the potential for natural colonization include physical and biological features of the site itself. Plants growing and reproducing on the site will reestablish after deposition of dredged material if the deposit was not too thick and if new substrate conditions are not prohibitive. Plants growing and reproducing near the area will establish only if seeds blow or are carried onto the site, if rhizomes or other vegetative reproduction forms extend onto the site, and if the new substrate conditions are not prohibitive.

(2) Planting selected species. Standard practices in agronomy are usually sufficient to handle plant propagation on upland sites. With appropriate planning and management, any site can be vegetated within a few years and most sites within a year. Planting upland sites ensures that desirable vegetation grows there, that substrates stabilize rapidly, and that aesthetic appearances of disposal sites improve faster. The chief disadvantage over natural invasion is the cost involved with site preparation and plant propagation and establishment.

(3) Combining natural establishment and planting. A combination of the two methods of vegetation establishment may be beneficial. Allow invasion to stabilize the substrate and start modifying the sediments, then plant a different type of vegetation when the season or timing or soil conditions are more suitable. The reverse also is possible: to get immediate benefits of selected plantings, plant the site, then allow the site to proceed in natural successional stages. Also, use subsequent deposits of dredged material to set back vegetation succession to a more desirable stage.

d. Selecting Plant Species and Propagule Type.

(1) Selecting plant species.

(a) If the site is to be planted, advance consideration must be given to the plant species that will create the desired habitat for the target wildlife species. An initial selection of species should be made during the planning phase, even though once the site is established, alternate species may prove to be more acceptable and be substituted for those originally selected (item 32). Numerous species are suitable for planting upland dredged material sites (item 39). Item 13 identifies, by state, 250 species or species groups that are of benefit to wildlife and adapted to grow on dredged material and presents species growth characteristics, habitat requirements, ranges, and tolerances of 100 of these. Item 45 identifies 50 species generally useful for dewatering and decontaminating dredged material. Item 54 gives growth characteristics of many tree and shrub species suitable for confined upland disposal areas. Items 12, 39, and 73 summarize data on plants known to grow on dredged material sites.

(b) Other species of more local character are available, and many species with unknown tolerances and adaptability may prove useful after field testing. Local soil conservation service personnel and agronomists will be able to provide updated information on species and new varieties. Selection of species or species mixtures to be planted at a particular disposal site must include consideration of project goals, climate, substrate characteristics, plant species characteristics, plant species availability, ease of propagation, management requirements, and costs. Certain species mixtures are commonly planted, such as a clover and a grass species, to take advantage of the different properties of each. Occasionally the mixture will not be successful because of interactions among the species and because the soil is too acidic, infertile, or compacted.

(2) Selecting propagule type. Items 32 and 39 give the best propagule types for selected plant species, based on criteria of availability and cost, ease of collection and handling, ease of storage, ease of planting, occurrence of disease, and need for rapid vegetation establishment. In general, seeds are cheaper and easier to work with than vegetative propagules such as cuttings, sprigs, or seeding in upland habitats. However, some plant species and planting situations require vegetative propagules, e.g., to rapidly stabilize the exterior of a sand dike.

(3) Handling plant material. If commercial seed sources are not available, collection and storage of wild seeds should follow the guidelines in item 32. Some desirable species are available as transplants (potted, balled and burlapped, or bare-rooted nursery stock). However, many upland plants that are desirable as long-term cover and food sources, such as trees and shrubs, are not commercially available.

e. Preparing and Planting the Site.

(1) Substrate modification. Once the dredged material has been placed and dewatered sufficiently to allow equipment access, it can be modified as necessary. Modifications will usually be directed toward preparing the substrate for vegetation establishment, and will depend on the condition of the substrate and the exact design of the project. In upland habitats, these activities are largely agronomic.

(a) Mechanical modification. The site may require grading to change the topography that resulted from disposal, e.g., to make the slope uniform by removing depressions or mounds, increase relief by making depressions or mounds or altering the slope, make islands, or raise low spots. Variation in texture of the sediments results either intentionally by disposal of more than one type of material or naturally through hydraulic sorting during disposal. This variation may need to be reduced to a more uniform soil for ease of seedbed preparation. This can be done by repeated passes with a blade or deep plowing followed by disking. If possible, grading should be done at the time of year when precipitation is lowest to reduce erosion of the bare soil. Seedbed preparation includes plowing or disking one or more times to break up clumps and aerate the soil, fill or cover desiccation cracks, even out moisture content, destroy unwanted vegetation that may have invaded, turn under green manure, incorporate soil amendments, and in general improve the quality of the substrate. Preparation is best done several months prior to planting and again just before planting, if labor and equipment are available. Success of the site may depend especially on this process.

(b) Chemical modification. Prior to final mechanical seedbed preparation (preferably several weeks to months ahead), the substrate at the site should be sampled and the soils analyzed chemically in the same fashion as for site characterization. Their properties may have been altered by dredging and dewatering from what they were in the initial tests. Some of the common problems that may be found include high salinity levels, soil acidity or alkalinity, or lack of one or more of the essential plant nutrients at levels sufficient to support good plant growth. These can be corrected with soil amendments, leaching, or other techniques (item 32).

(c) Biological modification. Biological modification of the substrate may also aid in the success of the project. This could include such things as removal of existing and competitive vegetation by cutting, short-lived herbicide application, or cultivation; growth of a preliminary green fertilizer crop; or addition of farmyard manure, sewage sludge, etc., on light-textured sands to improve their nutrient- and moisture-holding capacity. If legumes are to be grown on the site, the seed should be inoculated with the proper strain of Rhizombium bacterium to improve chances of fixing adequate amounts of atmospheric nitrogen.

(2) Timing. Timing of all factors related to plant establishment is an important consideration in habitat development. Adequate planning will have allowed lead time to locate, obtain, and prepare sufficient amounts of viable seeds or vegetative propagules, including any period of seed dormancy. Timing of planting will strongly influence plant success. For example, seeding warm weather annuals before the last cool period in spring will result in heavy crop damage, and seeding the same seeds in midsummer will result in heat and drought stress during sprouting. Seeding of cold weather species too early in the autumn will result in sporadic germination, increased chances of insect infestations such as army worms, and heat and drought stress. Optimum seeding times vary with climatic regions and photoperiods, and local agronomic authorities should be consulted before planting. Refer to items 32 and 39 for species-specific details on timing.

(3) Planting.

(a) Temperature. Vegetative propagules may be planted any time the ground is not frozen and any time the day temperatures average less than 68°F.

In general, March to May is best for warm weather plants and September to November for cold weather plants over most of the United States. In the Deep South, transplanting is usually done successfully from October through May, with June through September being too hot. Dormant propagules may be more readily transplanted in winter months. Propagules held in storage inside a nursery or greenhouse should not be planted until temperatures at the field site are at least as warm as the storage area, to lessen shock. Propagules held in a shady area should be gradually acclimated to sunny conditions if the site is in the sun, to prevent blistering and death of leaves and plant shock. General planting methods are given in Items 32 and 39; specific recommendations for local conditions can be obtained from the Soil Conservation Service or county extension service agents.

(b) Methods. Methods of planting vary with the propagule type. Seeds should be sowed in a well-prepared seedbed that has been plowed and/or disked to a depth of at least 6 inches. It is important to consider planting techniques and equipment, seeding rates and depths, and seed and soil treatments when using seed propagules. For transplants, types of propagules, planting techniques and equipment, transplant spacings, timing of planting, plant growth habits, and long-range project goals are all important factors in determining site success (item 32).

6-5. <u>Engineering Design of Upland Sites</u>. Guidelines for substrate design and sediment protection and retention apply to both a new disposal area or one that may already have a retention structure and some material placed. Design should be based on information gathered during the site description, on results of field and laboratory tests, and on the requirements for the planned habitat development. The majority of the information in this section was compiled from items 17, 32, and 62. Dredged material may be placed by either hydraulic or mechanical methods. The hydraulic pipeline dredge is the most commonly used and will continue to be the major source of dredged material to be used for upland habitat development. Hydraulic transport of material assumes additional prominence when one considers that the newer concepts for dredged material handling systems, involving direct pumpout of hopper dredges, temporary containment basins, or bucket-loaded scows, usually involve final disposition by pipeline. The pipeline dredge can dispose of material in upland areas through the use of shore lines or shallow-draft floating pipelines.

a. Substrate Design.

(1) Elevation. Substrate design for upland habitat development includes determination of site elevations, slope, orientation, configuration, and size (area and volume). The design must provide for placement of dredged material to a stable elevation within the desired elevation limits, allowing for settlement due to consolidation of both the sediments and foundation material. For fine-grained sediments, the substrate must be designed to provide adequate surface area and retention time for sedimentation of suspended solids. Procedures for substrate design generally follow those established by

items 56 and 62 for the design of conventional containment areas. The determination of substrate elevation is governed by two limitations: the project requires placement of a given channel sediment volume, and the size to handle this volume within elevation limits must be determined; or the project requires a substrate to be constructed within given size limits, and the volume of channel sediment to construct this substrate must be determined. In either of these cases, a correlation between in situ sediment volumes and volumes occupied by the dredged material must be determined. The first step is to calculate void ratios by determining water content of samples of the sediments to be dredged. The second is to compute the void ratio of the dredged material after dredging and deposition (items 56 and 62).

(2) Sedimentation of solids. Confined disposal areas with primarily fine-grained dredged material should be designed to retain solids by gravity sedimentation during the dredging operation. Solids retention is directly affected by the size of the confinement area (particularly length and depth), inflow rate (dependent on dredge size and operation), physical properties of the sediment, and salinity of the water and sediments. Items 56 and 62 detailed separate design procedures for determining sediment retention time requirements for fresh and saline sediments with continuous disposal. In addition, these procedures include factors influencing efficiency of the substrate containment, effects of short-circuiting, ponding depth, weir placement, and shapes of containment. In the event that substrate containment does not provide an adequate gravity sedimentation basin, then one of the following alternatives must be exercised:

(a) The size of the site must be increased.

(b) A smaller dredge must be used.

(c) Intermittent dredging and/or disposal operations must be initiated.

(3) Weir design. Retention structures used to confine dredged material must provide a means of releasing carrier water back into the waterway, which is best accomplished by placing a weir within the containment area. Effluent quality can be strongly affected by the design and operation of the discharge weir, with the weir length and ponding depth having the greatest control on this quality. Item 82 developed a design procedure for defining weir length and ponding depth to minimize the discharge of solid particles into the waterway.

(4) Dredged material settlement. Settlement will occur following completion of the dredging operation because of the self-weight consolidation of the dredged material layer and/or the consolidation of compressible foundation soils. Estimated settlements may be determined by procedures presented by item 62. Once loading conditions are determined, ultimate settlements that occur after the completion of 100-percent primary consolidation can be estimated from laboratory consolidation data. This settlement is not as critical as for wetland habitats, but is important because of the ponding effect it

causes. Time rates of consolidation for both the dredged material and foundation soils are required to determine the relationship between the desired final substrate elevation and time. If the data from the laboratory tests reveal that settlement will not meet desired elevation requirements, an adjustment to the substrate configuration must be made to raise or lower the initial substrate elevation as required.

b. Substrate Protection and Retention.

(1) Requirements for a structure. Data gathered for the site description should be used to determine if a protective or retention structure will be needed for the upland site. Engineering data collected at a specific site should determine: amount and character of material to be protected or retained, maximum height of dredged material retained above the firm bottom, degree of protection from waves and currents required, duration of the structure, foundation conditions at the site, and availability of construction material. All habitat development sites may require a structure for protection of the perimeter from erosion caused by currents, waves, or tidal action. Particular concern should be given to the effects of any proposed structure on existing current or wave patterns. A structure positioned so that it constricts the water flow will increase local current velocities or reflect wave energies, and thus may encourage erosion. All habitat development sites may require structures for retention of the dredged material to allow it to consolidate, to control the suspended solids content of the effluent, or to protect surrounding habitat or adjacent structures. Site hydraulics, the properties of the sediment to be dredged, the time over which disposal will occur, and the existing site characteristics are closely interrelated in determining the need for such structures.

(2) Selection of structure. The protective or retention structure should meet four conditions:

(a) Suitability to the project goals of dredged material disposal and habitat development.

(b) Practicality and ease of construction.

(c) Ease of maintenance.

(d) Reasonableness of cost.

Item 17 evaluates several protective and retention structures considered technically feasible for use in terrestrial habitat development and presents information on structure selection, applicability to specific site conditions, and conceptual procedures for design and construction. The most feasible structures are often dikes constructed from filled fabric bags or from sand in moderate to low wave-energies in temperate climates (item 17). The term "fabric bag" covers products from several producers of sacklike containers that can be filled with sand, sand-cement, or concrete and used as building blocks for breakwaters, groins, revetments, or containment dikes. Rock and rubble from new work dredging can also be used.

(3) Design of structure. EM 1110-2-1902 and EM 1110-2-2300 provide proven methods for design and construction of earth- and rock-filled structures. Those procedures should be used to supplement engineering considerations of elevation requirements and earth and water pressure forces. Internal structures may be advisable. Cross and spur dikes are used to control circulation within a disposal area, with the cross dike commonly employed to divide large disposal areas into smaller cells, and spur dikes employed to interrupt direct slurry routes between the inlet and outlet. The cross dike is the more significant of the two structures for habitat development purposes, since use of a cross dike allows flexibility in disposal including incremental filling and separation of dredged material by grain size. (See Figure 15-2, Chapter 15, for riprapped structures and cross dikes used at an upland habitat site.)

(4) Construction of structure. Site-specific factors affecting construction techniques are: equipment accessibility, wave and current conditions, tidal range, water depth, bottom conditions, and distance from the dredging site (item 17). The construction material used and method of construction are significant factors. In addition to the fabric bags previously discussed, three basic types of retention structure construction exist: hauled dikes, cast dikes, and hydraulically placed dikes (item 30). Construction techniques for retaining walls, sills, breakwaters, gabions, and other structures are highly site specific and should be determined on a case-by-case basis (item 30).

6-6. Ecological Design of the Upland Sites. Planning for a habitat development site should be based on sound ecological principles and should attempt to make efficient use of available resources in reaching the goal. The two major resources that can be manipulated for habitat development are substrate (in this case, dredged material) and vegetation. All previous aspects of planning should be united in the ecological design of the site for proper placement of dredged material and vegetation.

a. Placement of Dredged Material. Many aspects of the engineering design of an upland disposal site are directly related to the site's potential biological characteristics. Physical appearance of the site is particularly important, and structures, configuration, size, elevation, topography, timing, and site interaction with surrounding habitats must be considered for ecological integrity of the upland site.

b. Placement of Vegetation. Presence or absence and patterns of vegetation are critical factors in habitat development. Such ecological concepts as structural diversity, community size, species patterns of abundance, and biotic succession are pertinent. Specific concepts that should be applied to upland habitat design are diversity, ecological succession, habitat patterning, and vegetation structure and function.

6-7. Dredging and Disposal Operations.

a. Construction. The first step in construction of an upland habitat development site is to build a protective or retention structure, if called for in the project design, or to modify an existing structure or site (e.g., raise a dike or add drainage). Some site preparation may be necessary, perhaps construction of an access route or removal of vegetation. Access for equipment and pipes should be built to minimize damage, especially to wetlands. Unless the project calls for shallow disposal and recovery of plants present on the site, vegetation to be covered should be mowed or cut to prevent recovery after disposal or to prevent dead branches and shrubs from protruding. Clearing and grading are required along the dike alignment to allow construction.

b. Dredged Material Placement. A significant amount of material rehandling is sometimes required in developing upland habitat because the final distribution of material at the site is important. This handling can be reduced if the initial location and distribution of the coarse- and fine-grained fractions of the dredged material are controlled. One means of control is to take advantage of the differential settling characteristics of the various sized particles in the dredged slurry. Another means is to operate the dredging plant and peripheral equipment in a manner that will produce the desired substrate (item 4). For the majority of disposal operations, the criteria for locating the discharge pipeline in the disposal area have been to maintain an adequate flow distance relative to the weir, keep the discharge end of the pipeline a safe distance away from the interior slope of the dike, and minimize the pumping distance from the dredge. The criteria are directed at preventing short-circuiting or channelization of the flow through the containment area, avoiding scouring damage to dikes, and minimizing pumping costs. Some modifications of these pipe location criteria may be required if advantage is to be taken of particle size differential settling characteristics for habitat development. Coarse-grained material encountered during dredging operations can be taken advantage of with end-of-pipe operations. If the character of the sediment-water slurry being transported is known beforehand or can be determined by monitoring at the dredge or at the end of the pipe, then the coarse material can be diverted by use of a wye connection without interrupting the dredging operations or the dredging sequence. The diverted material can be placed directly in the desired location hydraulically or stockpiled for later use in habitat development. Stockpiling and subsequent rehandling of the material are roughly equivalent to obtaining the material from a source outside the disposal area and involve the use of additional or supplementary equipment.

c. Containment Area Operation. Activities during substrate material placement are aimed at the retention of solids and production of an effluent that will meet criteria for release into the waterway. Operational difficulties, such as channelization of the dredged slurry and insufficient ponding depth, may result in excessive amounts of solids leaving the disposal area through the weir. This is counterproductive and usually violates laws and regulations. Therefore, it is recommended that during and after the disposal operation a well-planned monitoring program be implemented to ensure that suspended solids in the effluent remain within acceptable environmental limits. Suspended solids retention can sometimes be increased by increasing ponding depths through efficient operation of the weir. Concepts of containment area management instituted immediately following the completion of a disposal operation are also important to successful implementation of a habitat project. The most important aspect of dredged material disposal area management was to remove all surface water as fast as possible to enhance surface drying (item 4). This conclusion can be extended to include terrestrial habitat development since extensive site activity must usually wait until the substrate is trafficable. In addition, working the area to a gentle slope toward the effluent point allows efficient drainage of surface water, and evaporative dewatering can be supplemented by transpiration by vegetation.

d. Quality Control. Specifications for all phases of construction should be detailed and clear. Thorough inspection of all operations will ensure that the work is in compliance with plans and specifications for upland habitat development and any mitigation requirements, and will mean fewer post-dredging operations and lower project cost.